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MULTI-MICROPROCESSOR CONTROL OF A PRECISION PAN AND TILT HEAD

Authors: E C E Charlwood and C J Turner

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ROYAL SIGNALS AND RADAR ESTABLISHMENT

Memorandum 4252

TITLE: MULTI-MICROPROCESSOR CONTROL OF A PRECISION PAN AND TILT HEAD

AUTHORS: E C E Charlwood, and C J Turner

DATE: January 1989

SUMMARY

This Memorandum describes further work undertaken on the microprocessor system used to control a heavy duty precision pan and tilt head previously reported in RSRE Memorandum 3996. A multiprocessor architecture was used to provide interactive control of the head and a capability to gather and track targets automatically with a thermal imager as the tracking sensor. The time taken to gather the target and establish a stable track was demonstrated to be of the order of 0.25s against a variety of aircraft targets with crossing rates up to 100mR/s.

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E C E Charlwood and C J Turner

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1 INTRODUCTION

RSRE Memorandum 3691 (1) described the mechanical and electrical design of a heavy duty precision pan and tilt head that was controlled by digital servos and driven by stepper motors. RSRE Memorandum 3996 (2) described improvements to that pan and tilt

head which included the initial work on controlling the head from a single MC68000 microprocessor. This Memorandum describes further work undertaken on the microprocessor system to provide interactive control of the head and the capability to track automatically a manually acquired airborne target. The objective was to gather the target and establish a stable track as quickly as possible with an existing thermal imager based hotspot detection system.

2 MULTIPROCESSOR SYSTEM

Memorandum 3996 (2) described the use of a single Philips PG2020 microprocessor card installed on a VME bus to develop the control algorithm for the azimuth stepper motor of the pan and tilt head. The real time multi-tasking kernel used was pSOS68K, a product of Software Components Group Inc. Within a single MC68000 microprocessor environment, it provided:

* Fully preemptive Process switching,
* Process timing primitives,
* Process synchronisation using event flag fields,
* Interprocess communication based on a message exchange concept,
* Memory allocation and error exception handling,
* Terminal I/O support and
* An online interactive monitor for

    Code debugging,

    Code download from the host development system and

    Error reporting and recovery.

The MC68000 microprocessor software was developed on a DEC VAX computer using the OREGON PASCAL-2 cross compiler run under the VMS operating system. During development the generated code was downloaded to the RAM of a target MC68000 microprocessor card so that it could be tested and debugged. The final code was loaded into EPROMs to provide a fully stand alone system.

It was realised from processor load data obtained during the early stages of development that a single PG2020 microprocessor card would not support both control of the pan and tilt head, in azimuth and elevation, and target tracking. Using a top down design approach, it was seen that the problem could easily be split into several well defined processes, with a limited amount of interprocess communication. Therefore further PHILIPS PG2024 microprocessor cards were added to the VME bus to provide a multi-microprocessor environment. Each independent

microprocessor was provided with its own multi-tasking pSOS68K kernel. A diagram of the system is shown in Fig 1.

2.1 Interprocessor Communication

The pSOS68k system already provided well defined mechanisms for process synchronisation and message handling within a single microprocessor card. This concept was extended by the development of a library of primitives to allow similar mechanisms across the VME system bus. The data structures required to support the extension were maintained in a global VME memory block. Although this approach does not make the most efficient use of the VME bus, it more than satisfies the required global data transfer rate of the system. Being simple in concept it readily permits system expansion and modification. The library was developed in MC68000 macro code and designed to present an interface to the user in terms of PASCAL data structures and procedure calls that complied with the OREGON PASCAL-2 compiler and linker standards.

2.2 Process Descriptions

Each microprocessor in the system supported one major process as shown in Fig 1 together with a number of associated minor processes. The functions of the major processes are:

* HCON - The head control process, which monitored a rate control joystick, processed the external hot spot tracker data, and produced the necessary drive demands for the motor control processes AZDR and ELDR.

* INTC - The interactive control process, which provided the terminal interface for the input of system commands and configuration data and the output of a continuous display of system status data.

* AZDR - The azimuth motor control process.

* ELDR - The elevation motor control process.

* DLOG - The data recording process to enable off line analysis of system performance.

3 MANUAL CONTROL

A joystick was used to control the head motors manually. It was monitored through an A/D converter by the HCON process. The output was shaped by means of a configurable look up table and used to produce the necessary demands to the motor control processes AZDR and ELDR. Associated with the joystick was a

switch to select manual or automatic target tracking. Further control of the system was effected by terminal keyboard entry.

The terminal keyboard allowed system parameters to be modified dynamically. It also permitted a set of high level head commands to be entered. The commands included:

* Set/modify the working arc of the head.
* Position the head by means of an intercept profile. (See section 5.)
* Command the head to move at defined rates.
* Scan defined areas in azimuth and elevation at defined rates.
* Save and recall head positions.
* Enable and disable system data logging.
* Modify system parameters:

  Permitted level of head acceleration/deceleration.

  Kalman tracking filter parameters.

  Modify joystick shaping table.

4 AUTOMATIC TARGET TRACKING

In order to demonstrate automatic target tracking by the head an existing thermal imager based hotspot detector was used which transmitted data to the microprocessor system. The position of the head was measured by sampling the head encoders and these data were combined with data from the hotspot detector to provide a measurement of the present target position in terms of absolute angular elevation and azimuth. To smooth the measurement noise a Kalman filter was used to produce estimates of the target position and velocity. These estimates were used to generate track demands to the head driver processes AZDR and ELDR which controlled the head motors. This control loop ensured that the point of aim of the head was maintained automatically on the target.

4.1 Hotspot Detector

The hotspot detector processed the CCIR video output of the thermal imager to produce the coordinates of a target within the field of view of the imager in the form of two 8 bit data words. To facilitate target selection three controls were available to the operator; threshold, gate size, and target size. The

threshold controlled the brightness level above which a detection could be triggered, the gate size controlled the size of the rectangular portion of the video image within which target detection was allowed, and the target size controlled the minimum rectangular size to be considered as a target. The thermal imager used was a TICM Class II fitted with a x20 magnification objective telescope providing a field of view of 54mR x 36mR. If a target was detected then the data were passed to the microprocessor system. The maximum data rate was the CCIR video field rate of 50 Hz. The resolution of the data was nominally 0.13 mR.

4.2 Kalman Tracking Filter

A Kalman filter is a recursive algorithm which estimates the values of the variables of a stochastic system from measurements that contain randomly varying noise. It can also be used to estimate variables which are not directly reflected in the measurements made of the system. The application of a Kalman filter requires the definition of a linear mathematical model of the system. When a simplified model is used in order to reduce computation time it is necessary to introduce pseudo-errors to account for non-modelled effects and to prevent incoming data being ignored as the variance associated with the estimates becomes significantly smaller than that associated with the measurement (3).

The Kalman tracking filter used assumed a constant velocity model of the target. Pseudo-errors were introduced by the inclusion of a variable called plant noise which was used as the coefficient of a term in the variance calculations that introduced a variance associated with a target acceleration whose mean value was zero. This imposed a lower limit to the variance associated with the estimates and thus ensured that the filter remained sensitive to incoming data. Since the coordinate systems of the error data and head control were the same, rectilinear, a single dimension filter was used and the data partitioned into azimuth and elevation.

4.3 Manoeuvre Logic

At each recursion of the Kalman tracking filter the measured position of the target was compared to the predicted position using the smoothed estimates of position and velocity obtained from the previous recursion. If the position deviated by more than three times the standard deviation of the smoothed estimate then the plant noise was increased so that the filter took more notice of the incoming data. Using an initial plant noise coefficient of 2.0 the deviation permitted varied from 1.4mR immediately after filter initialisation to a steady value of 0.62mR after 1.5s. If the time since the last sensor update exceeded a preset value, typically set to ten fields, 200ms, then the target was considered lost and the filter was reinitialised.

4.4 Filter Initialisation

Since the Kalman filter is a recursive algorithm initial values of the smoothed estimates of target position and velocity need to be defined. This can be achieved by taking two measurements of position over a known time inteival. It is essential that the direction of target movement is detected correctly otherwise the resulting head demand would cause the target to move out of the field of view of the sensor. To reduce the chance of this happening filter initialisation was inhibited until three consecutive sensor updates were received which represented a target point travelling in a uniform direction with a realistic angular acceleration, typically less than 50 mR/s^2. When this condition was met the first and third values were used to initialise the filter.

5 HEAD CONTROL

The two driver processes, AZDR and ELDR, controlled the motion of the pan and tilt head, responding to demand messages from a global message exchange and the present state of the head. The stepper motors on the head were controlled using a purpose built head interface which accepted direction and rate data from the driver process and outputed a pulse stream at the required frequency to the motor. Acceleration control was achieved by incrementing or decrementing the rate within a control loop that was synchronised to a period of 1ms. This period was derived from the 16MHz SYSCLK signal on the VME bus by means of a dedicated count down timer which could be asynchronously reset when required.

When a position was demanded a profile algorithm was used to produce a head velocity profile to intercept the target as rapidly as possible such that at the point of intercept the head was travelling at the same angular velocity as the target. The maximum time to decode a demand message and compute the desired profile, using software real arithmetic, was measured in tests as 4.5ms. A value of 5.0ms was allowed for this delay in the algorithm that executed the profile.

5.1 Head Interface

The head position was measured using 16 bit encoders through a 2:1 gearbox and the head was driven by stepper motors as described in RSRE Memorandum 3996 (2). The hardware interface to the head consisted of two 16 bit parallel ports on the VME bus and a purpose built card to generate the pulse stream for the stepper motors. This card used binary rate multipliers (BRMs) to provide 14 bit resolution of the demanded head rate. The angular range of the encoders was π radians with a resolution of 48μR. The maximum velocity allowed was 0.59R/s and the resolution was 36μR/s.

The torque-speed characteristic of a stepper motor can be divided into three regions, a stopped region, a stepping region, and a sleving region (1). In the stopped region maximum torque is developed as a holding torque which will act as a brake on the load. In the stepping region the motor will start and stop following a pulse input provided the motor's limiting torque is not exceeded. The sleving region allows high speed running with reduced limiting torque. In this region the limiting torque falls to zero as the speed increases. If the load torque ever exceeds the motor's limiting torque it will stall and therefore lose synchronism with the input pulse stream. It was found that the stepper motor stalled when rate changes of the order of 40 BRM bits per millisecond, $1.44R/s^2$, were demanded. So a limit of 30 bits per millisecond was imposed, to ensure reliable operation and this yielded a permitted maximum acceleration of $1.08\ R/s^2$.

5.2 Control Commands

The driver processes, AZDR and ELDR accepted commands as demand messages from a global message exchange. The parameters of the commands referred to the angular motion of a target in space rather than that of the head so that the head could be manoeuvred to intercept the target. As described in RSRE Memorandum 3996 (2) an essential feature of the control strategy was preemption where the control algorithm gracefully aborted its present command and started to execute the new demand with the minimum of delay. When a new demand message arrived there was a maximum delay of 1ms before the present command was aborted and a further delay of up to 5ms before the new command was seen to be changing the speed of the stepper motors.

The primary commands were track, position and rate demands. The parameters of the track and position demands were target position, target velocity, time tag and timeout, whilst the parameters of the rate demand were head rate, time tag and timeout. Demands could be absolute, or relative to the present position and velocity of the head. They included a timeout, which would cause the head to stop if no further demands were received during the timeout period. All command messages were time tagged using a global millisecond clock so that the head control algorithms could compensate for the transit time of the message. This was particularly relevant when generating the profile of the manoeuvre necessary to achieve target intercept.

Secondary commands controlled head parameters which included the limits of the arc, acceleration, and maximum head speed. The head was monitored at each iteration of the control loop to ensure that it was never allowed to exceed the limits of the arc, whilst due note was taken of the displacement necessary at the present speed to decelerate the head to a standstill.

5.3 Track Demands

During automatic tracking the HCON process generated track

demands. These consisted of the absolute position and velocity of the target, from the output of the Kalman tracking filter, and the time at which the sensor update to the filter was received. From this data and the present values of head position, head velocity and system time, the present position and velocity errors were calculated by the driver process.

The magnitude of the position error determined whether the response was simply to change the rate at which the head was travelling or to make an intercept manoeuvre using the profile algorithm. The algorithm was designed to achieve rapid target intercept within the velocity and acceleration limits of the head. A single rate change only involved acceleration or deceleration whereas using the profile algorithm always involved both acceleration and deceleration.

If all track demands were satisfied using an intercept manoeuvre then excessive vibration of the sensor assembly would occur because each acceleration was always followed by a deceleration, these were always maximum in value and the manoeuvre would be repeated every 20ms.

The intercept manoeuvre was used when the position error was in excess of 2mR which generally only occurred when the Kalman tracking filter was reinitialised. Position errors below 2mR resulted in a single rate change where the new head velocity was the sum of the target velocity from the track demand and a velocity increment called delta_v to compensate for the positional error called pos_error.

This delta_v was derived from a defined delta_v/pos_error characteristic shown in Fig 2 as curve 1 which was arranged to take up the positional error over several update periods, so that subsequent updates could further refine the value. The characteristic was a continuous function combining a parabola to a straight line at a point of common slope, thereby damping the response of the head as the positional errors decreased. Further damping was achieved by reducing the acceleration when positional errors were small, as shown in Fig 2 curve 2.

The unit used for calculations in the driver processes was the resolution of the binary rate multipliers, and the delta_v/pos_error characteristic was implemented with rounded values to reduce computation time. The characteristic used was:

```
delta_v = N((|pos_error|)(pos_error)/32)  when |pos_error|<16

delta_v = N(pos_error - 8)                when pos_error>=+16

delta_v = N(pos_error + 8)                when pos_error<=-16
```

where N controlled the proportion of position correction and was set to 25.

The time taken to correct a given position error is shown in Fig 2 as curve 3.

5.4 Profile Algorithm

Any manoeuvre was considered to be one of three types:

Type 1. A one step manoeuvre in which there was a single acceleration/deceleration from the start velocity to the finish velocity.

Type 2. A two step manoeuvre in which there was an acceleration/deceleration from the start velocity to an intermediate velocity immediately followed by a deceleration/acceleration to the final velocity.

Type 3. A three step manoeuvre in which there was an acceleration/deceleration from the start velocity to a coasting velocity, then slewing at constant velocity to a predetermined position, immediately followed by a deceleration/acceleration to the final velocity.

The profile algorithm was implemented as a PASCAL procedure within each driver process. The procedure could accept three demand types as input, a track demand, a relative position demand and an absolute position demand. The flow diagram of the procedure is shown in Fig 3 and the essential features can be summarised as follows:

Determine Start Conditions
The present global time, head position and head velocity are solicited to enable the position and velocity to be calculated for the start time of the manoeuvre. The calculation of the manoeuvre start time includes a fixed time allowance for the profile calculation.

Track Demand
The input is tested to ascertain if it is a track demand. If it is not then the position demand is converted to an absolute position demand if necessary.

Tracking Error
When the input is a track command and the error between the present head position and the predicted position of the target is less than 2mR then a single change of rate is determined to achieve track correction, as described in Section 5.3. If however the input is a track demand and the error is greater than 2mR then the demand type is redefined as an absolute position demand and the right hand limb of Fig 3 is invoked. It must be remembered that this position is the position of the target and not the head.

Determine Total Displacement
The total displacement required is determined which includes a correction for the delay in receiving the demand.

Determine Start Type
If the head is currently stationary and the demanded final absolute velocity is zero then the manoeuvre can start

immediately. If however the demanded final absolute velocity is non zero then the manoeuvre has to start at a specific time in order to achieve the intercept. Should the head be currently moving then the manoeuvre is started at a specific position in order to achieve the intercept accuracy required of ± 1 encoder bit.

Determine Intercept Profile
After the parameters of the demand have been determined relative to the final position and velocity required the profile is determined in a similar manner to the technique described in RSRE Memorandum 3996 (2). Care must be taken over the value adopted for the maximum achievable head velocity since in this instance it needs to be relative to the final demand.

Load Profile Array
The resulting profile is broken up into a set of absolute head velocity demands together with their associated start condition and the whole loaded into a structured array that the control loop can read.

5.5 BRM Control

A section of code within the control loop was used to update the BRM register and so alter the velocity of the head. The loop was synchronized to 1ms using one of the M68230 timers on the appropriate parallel interface card. During acceleration or deceleration the BRM was incremented or decremented by a fixed amount. This amount was defined by the acceleration required by the profile. Where the change in velocity did not equal a whole number of increments it was essential that the fractional increment was added at the lower velocity, that is at the start for an acceleration or at the end for a deceleration. This minimised the error contribution to the final position caused by quantizing the velocity.

When a profile was executed that involved slewing at maximum velocity until a specific position was reached it was necessary to detect if that position was expected within the next 2ms and if so to suspend the control loop and continually sample the encoder until the specified head position was reached. The control loop timer was then reset to ensure that subsequent time steps for incrementing the BRM were synchronised to the time that the head passed the specified position.

6 EXPERIMENTAL RESULTS

6.1 Data Collection

In order to record the movement of the pan and tilt head an extra process, called DLOG, was added to the microprocessor system to receive data messages from other processes for storage. It was implemented on a separate processor on the VME

bus so as not to interfere with the real time performance of the rest of the system. It buffered the incoming data messages and outputed them in a compact form to a desktop computer, an ATARI 1040STF. The desktop computer received the data and filed them on 3½ inch microfloppy disks for offline processing.

Data were sent to the DLOG process, by the HCON process, each time the hotspot detector interrupted the microprocessor system. The data contained head position, target coordinates from the thermal imager, tracking status information, present values of various offsets, and a time tag. Using software developed on the ATARI 1040STF the filed data were verified by using the checksum field and then processed to produce graphs of the sensor error, and the head position. These graphs also showed the status of the Kalman tracking filter as tracking, initialising, or lost target.

6.2 Targets

During March 1988 the system was used to track aircraft targets of opportunity during the trials of other equipment. The targets tracked were both fixed and rotary wing and presented crossing rates up to 100mR/s.

6.3 Estimation Of Sensor Standard Deviation

The Kalman tracking filter required knowledge of the standard deviation associated with the measurement of target position. This value was obtained by logging the data from the hot spot detector while it was pointing at a single hot static target some 5km distant. The head was prevented from moving and sensor error data logged. The results for a sample size of 3292 are:

	Azimuth	Elevation
Standard Deviation	0.16mR	0.08mR

The values obtained for the standard deviations indicated that they were of the same order as one bit of error data.

6.4 Gathering The Target

The target to be tracked was acquired manually. This was achieved by observing the display from the hot spot detector and operating a joystick to control the head velocity so that the target was within a bounded area in the centre of the display. The controls of the hotspot detector were adjusted for optimum performance and then the mode was switched to 'track'. This caused the microprocessor system to enter the 'tracking mode', the first activity of which was to initialise the Kalman tracking filter. When that phase was completed, track demands were issued to the driver processes and, since they represented position errors in excess of 2mR, the profile algorithm was

activated to generate an intercept profile to gather the target. Subsequent track demands were satisfied as described in Section 5.3.

6.5 Time To Gather

To measure the time taken in the gather phase, a static hot target was selected and the head positioned such that the hotspot was at one corner of the central bounded area of the display, then the mode was switched to 'track' causing the head to move so that the static target was placed at the centre of the display. The resulting sensor error and head position graphs for azimuth are shown at Fig 4. The timetable of events during the gather phase was as follows:

Event	Lapsed Time Interrupts	ms
First Interrupt	0	0
End of Initialisation	3	60
First demand to the head	4+	95
First perceived movement	6	120
First occurrence of zero error	14	280
Stable Track established	18	360

The time taken to gather the target divides into two regions, the time taken to initialise the Kalman filter and the time taken to drive the head to the point of intercept. The results demonstrated that the minimum time required to initialise the Kalman filter and issue a demand to the head was 0.1s. The time required to move the head so that the target was on the boresight and to establish a stable track was a further 0.26s. The time taken to move the head is influenced by the acceleration and velocity limits of the head and the initial displacement of the target from the boresight. In this measurement the target was 7mR from the boresight at the time the hot spot detector first detected it.

6.6 Tracking Moving Targets

Example results are presented to illustrate how the performance of the system was affected by the characteristics of the error sensor data. The target aircraft was executing a series of climbing and diving manoeuvres. Sensor error and head position graphs for azimuth that resulted from tracking this aircraft which had a crossing rate of 24mR/s are shown at Fig 5. These graphs illustrate the manoeuvre used to gather the target and the values of sensor error obtained while the target was tracked. At the time of the target's first detection by the hot spot detector it was travelling at 18mR/s in azimuth relative to the head. The initialisation phase lasted 0.1s and the additional time taken to establish a stable track was 0.14s. The target presented a thermal profile which consisted of a single dominant hot spot and the head tracked the target smoothly because the data from the hot spot detector referred to

the same target point at each update and there were no missing data.

The time taken to gather this and similar targets was of the same order as that for a static target and they were all tracked until either inconsistent data from the hot spot detector caused the Kalman tracking filter to consider them lost or the Kalman tracking filter estimates gave rise to track demands that could not be achieved. Data inconsistency fell into two categories; one when the hot spot detector was unable to detect the target at all and the other when the thermal profile of the target was such that the detector selected a different point on the target at each update. The latter condition occurred for example with closer targets where they occupied a significant part of the thermal imager field of view. When the detector selected different points on the target at each update the Kalman tracking filter reacted as though the target was accelerating and increased the value of plant noise to become more sensitive to the incoming data. This eventually gave rise to head movements which caused the target to move outside of the field of view of the imager, data flow from the detector to cease and the tracking filter to consider the target lost.

By comparing the measured position of the target to that predicted by the tracking filter and determining the angular acceleration necessary to achieve such a difference it was possible to inhibit the update of the Kalman tracking filter when a preset value of acceleration was exceeded. In the present measurements a value of $100mR/s^2$ was used. While it was found that this technique improved the performance when tracking closer targets it required prior knowledge of the expected angular accelerations. If the preset value was set too low then the track was lost if the aircraft executed an evasive manoeuvre and if set too high the track was lost because insufficient of the inconsistent data were excluded.

To provide a contrast with these results experiments were carried out using an analogue positional servo control system in place of the microprocessor control system in order to highlight the anticipated different gather characteristics. The hotspot detector was coupled to this servo system and the results were collected by the same techniques. Fig 6 gives these results in the same format as those presented in Fig 5. It can be seen that the gather characteristics of the two systems are significantly different; the servo system presenting a smooth transition to target track over 0.5s as compared the microprocessor system which has a sharp transition to track after 0.25s. The times of themselves are not significant, it is the nature of the transition that distinguishes the two control techniques.

7 CONCLUSIONS

The work described in this RSRE Memorandum has demonstrated that microprocessor control of a stepper motor driven pan and tilt head can provide sufficient precision to gather and track airborne targets of interest given target positional error data

of the requisite quality.

It was demonstrated that a motor control loop period of 1ms was adequate for the precision required and that using the described velocity profile algorithm and a preemption strategy, time delay from first detection to first demand to the head was 5 image fields, 0.1s. The additional time required to establish a stable track was demonstrated to be 0.26s when the initial target to boresight error was 7mR. When track was lost the cause was attributable to one of two reasons, the mechanical limitations of the head or the quality of the sensor data passed to the tracking filter. To improve the system performance more sophisticated target extraction techniques are required to deal with the complex thermal profiles that targets present.

The work described in this Memorandum represents the first step in a programme to build a multi-microprocessor control system that uses inputs from sensors of differing resolutions and technologies to acquire, gather and track targets.

8 ACKNOWLEDGMENTS

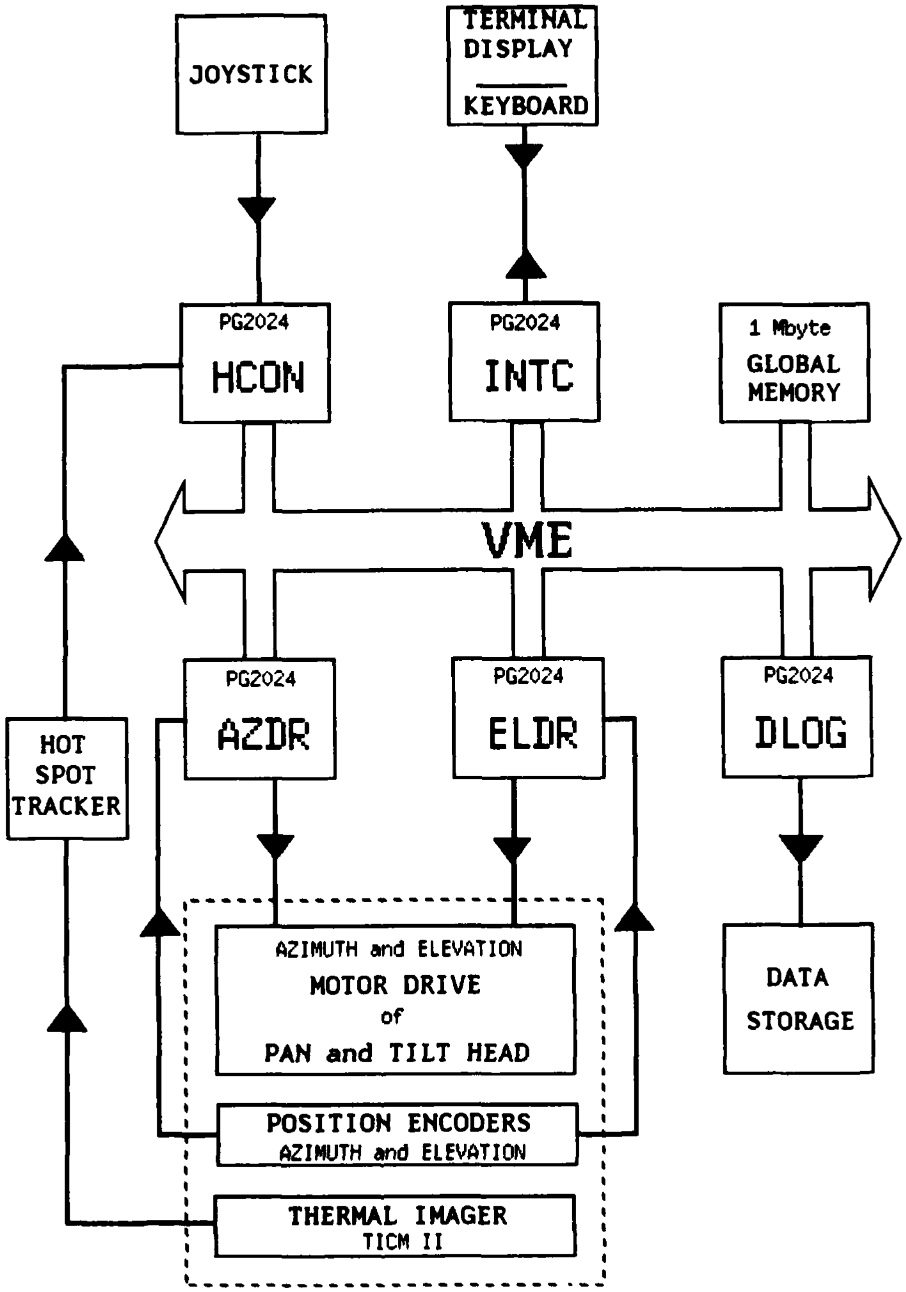
The authors wish to thank Mr J D Roberts and Mr M G Horey for useful technical discussions and Mr P N Griffith, Mr F Mansfield and Mr A Watkins for their assistance during trials.

9 REFERENCES

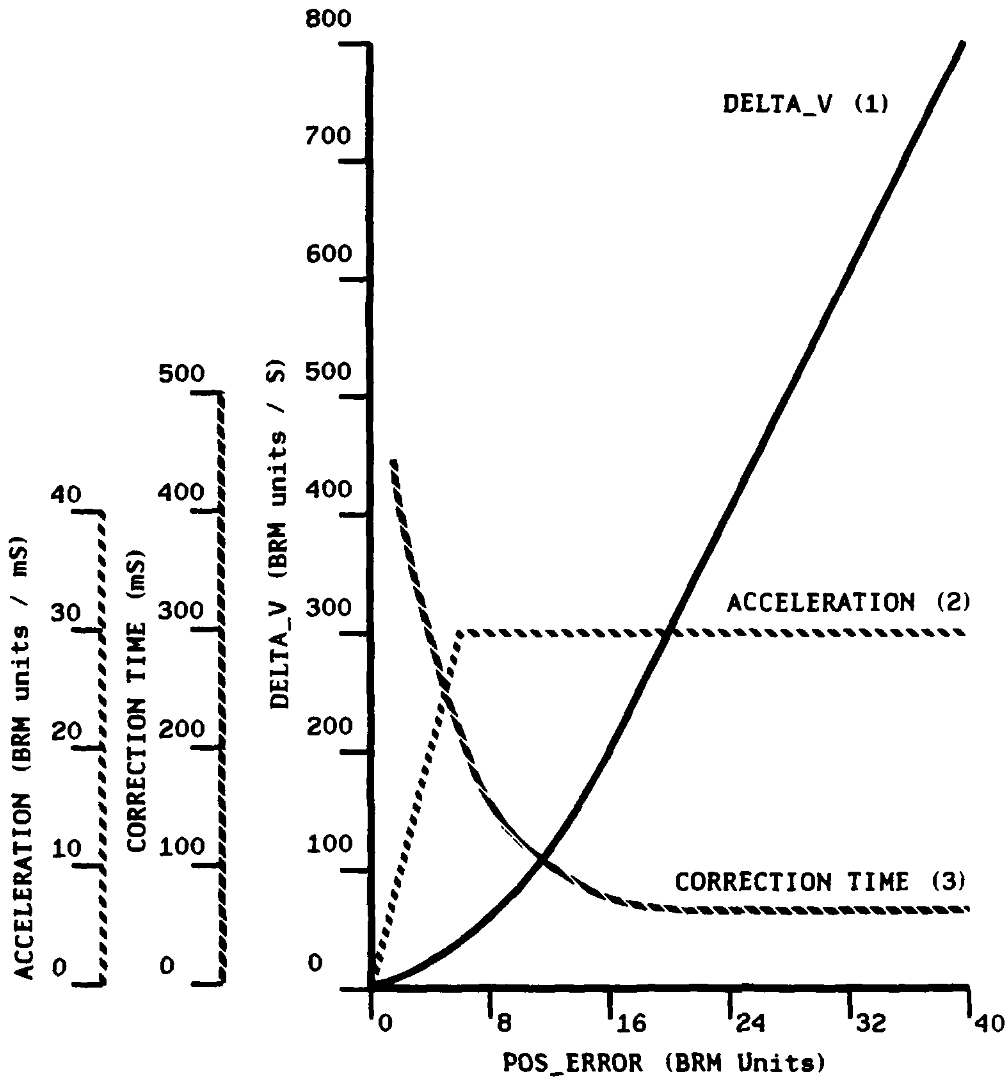
1. D Bagshaw, M R Brown, F Mansfield and J D Roberts, Heavy Duty Pan and Tilt Head - RSRE Memorandum No 3691 April 1984.

2. J D Roberts, E C E Charlwood, P N Griffith and F Mansfield, Improvements To The Precision Pan And Tilt Head - RSRE Memorandum No 3996 December 1986.

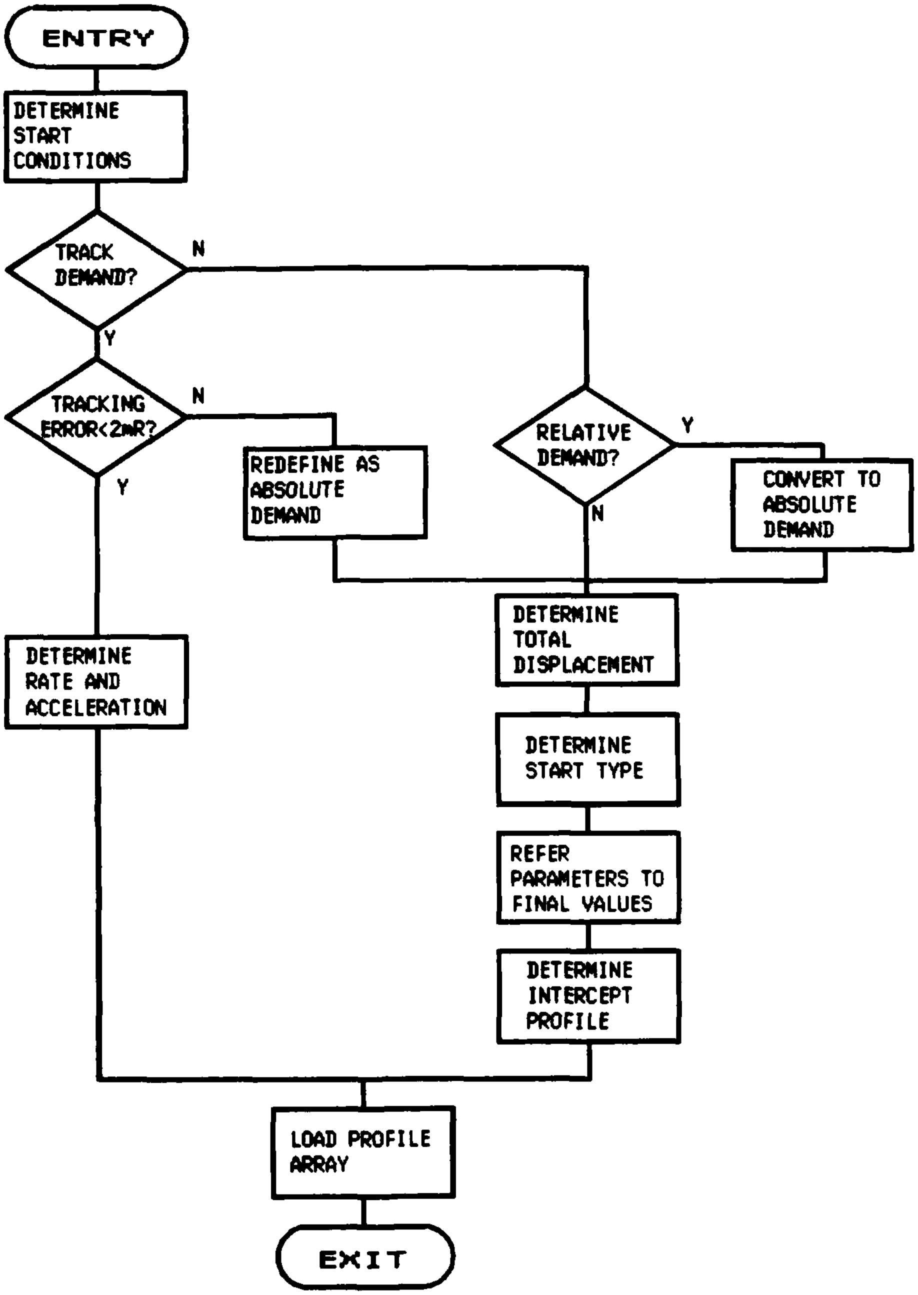
3. J J Burke, Understanding Kalman Filtering And Its Application To Real Time Tracking Systems - prepared for Electronic Systems Division, Airforce Systems Command, United States Air Force by The Mitre Corporation, Bedford Massachusetts USA - Ref ESD-TR-72-312 July 1972.



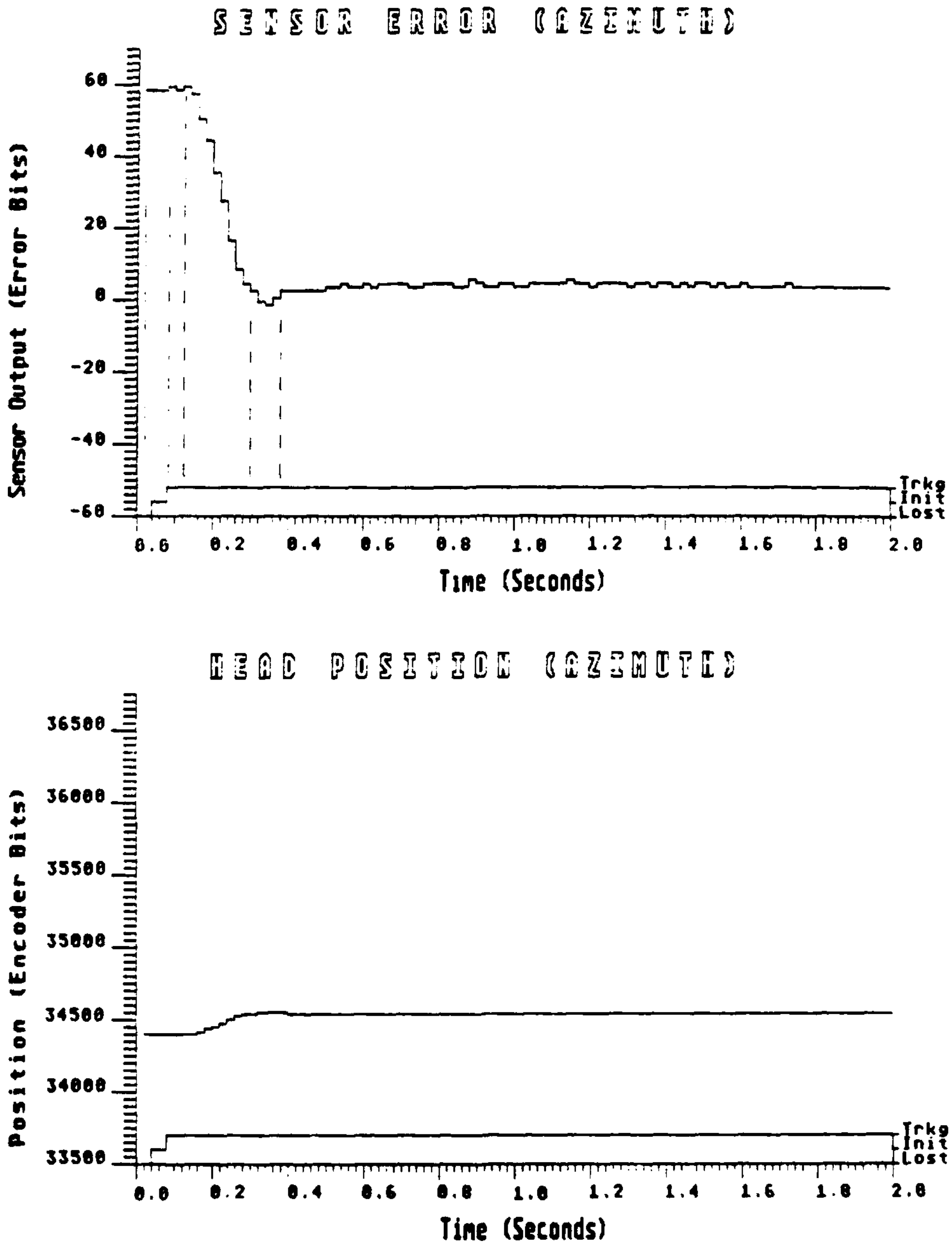
SYSTEM CONFIGURATION
Figure 1



DELTA_V / POS_ERROR CHARACTERISTIC
Figure 2

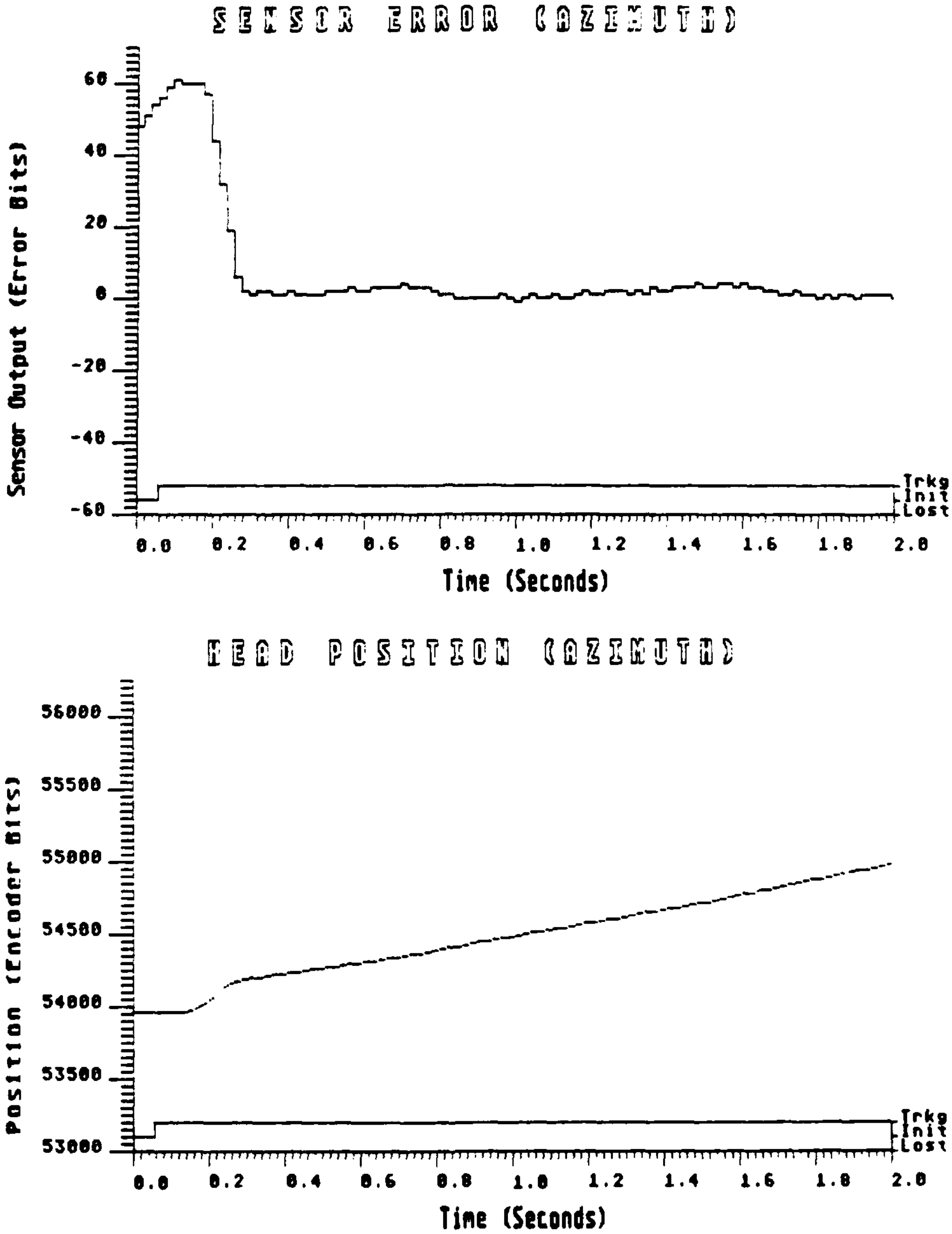


FLOW DIAGRAM
OF PROFILE PROCEDURE
Figure 3



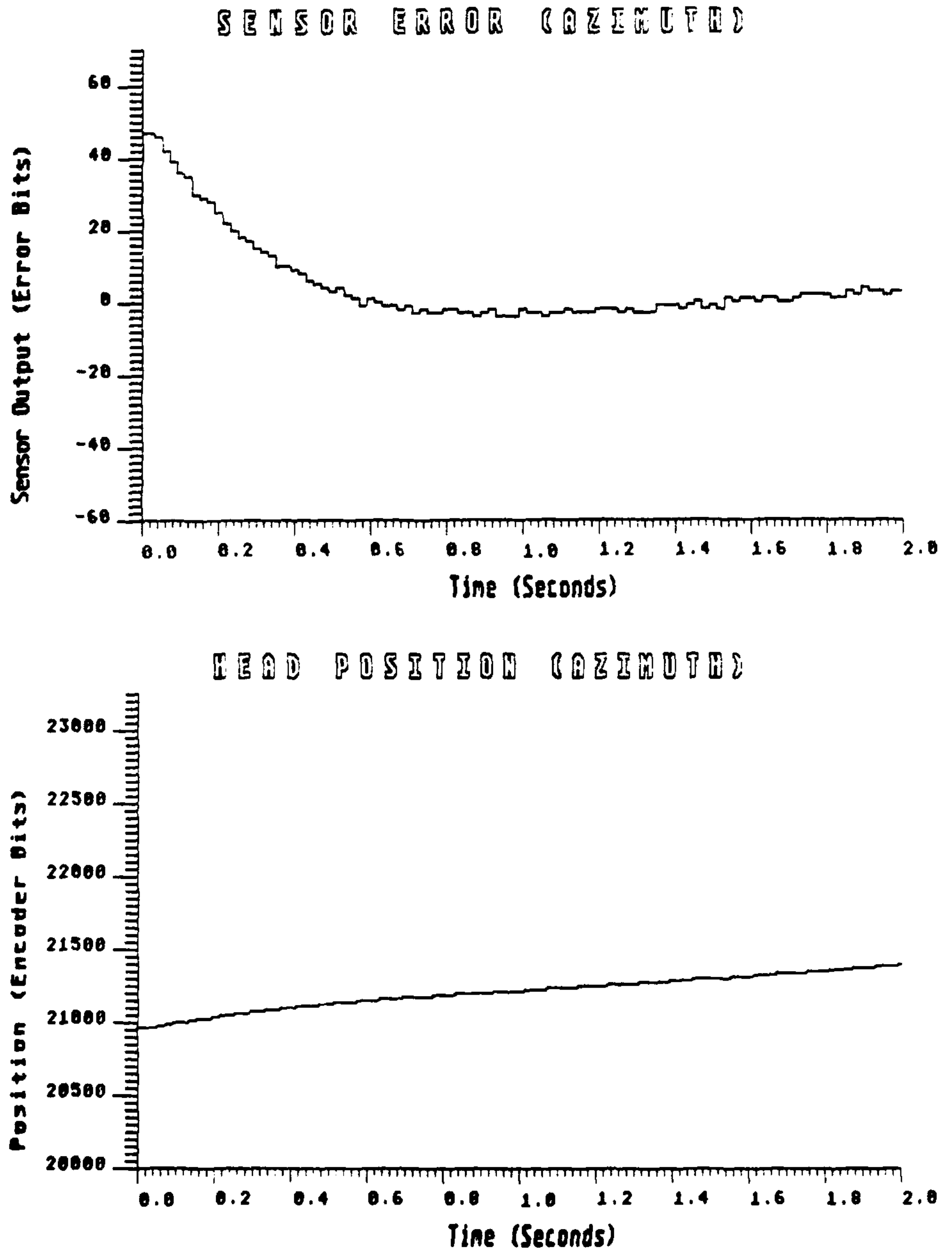
GATHER CHARACTERISTICS - STATIC TARGET

Figure 4



GATHER CHARACTERISTICS - MOVING TARGET

Figure 5



GATHER CHARACTERISTICS - ANALOGUE SERVO

Figure 6

DOCUMENT CONTROL SHEET

Overall security classification of sheet ..UNCLASSIFIED.......................................

(As far as possible this sheet should contain only unclassified information. If it is necessary to enter classified information, the box concerned must be marked to indicate the classification eg (R) (C) or (S))

1. DRIC Reference (if known)	2. Originator's Reference Memo 4252	3. Agency Reference	4. Report Security Classification Unclassified
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MULTI-MICROPROCESSOR CONTROL OF A PRECISION PAN AND TILT HEAD

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Abstract

The Memorandum describes further work undertaken on the microprocessor system used to control a heavy duty precision pan and tilt head previously reported in RSRE Memorandum 3996. A multiprocessor architecture was used to provide interactive control of the head and a capability to gather and track targets automatically with a thermal imager as the tracking sensor. The time taken to gather the target and establish a stable track was demonstrated to be of the order of 0.25s against a variety of aircraft targets with crossing rates up to 100mR/s.

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